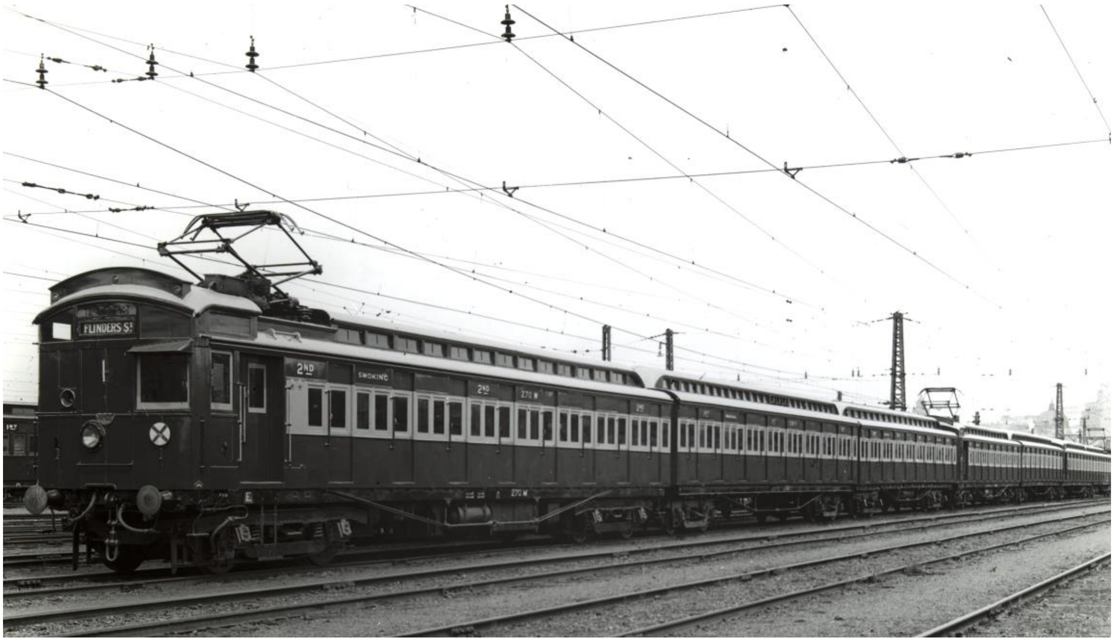
Engineers Australia

Engineering Heritage Victoria

Nomination

Engineering Heritage Australia Heritage Recognition Program

Electrification of Melbourne's Suburban Railway Network



APRIL 2019

1. Introduction

The first steam locomotive hauled passenger train service in Australia commenced operation from the site of the present Flinders Street station to Port Melbourne in 1854 under the privately owned Melbourne & Hobsons Bay Railway Company. Other suburban railway lines were constructed in the succeeding years by both private companies and by the Victorian Railways Department that was established by the State Government in 1856. By 1878 all railway lines and train operations in Victoria were consolidated within the Victorian Railways Department. The VR continued to expand railway services both within the growing Melbourne metropolitan area and regional Victoria. By the turn of the century, the suburban railway network included most of the present lines radiating out from the CBD stations along with some interconnecting lines and they were serving the expanding city with commuter trains hauled by steam locomotives.

After several assessments and deferments the Victorian Government resolved in 1912 to proceed with electrification of the suburban network. Work on this commenced in the following year, however progress was impeded by the First World War, particularly in respect to the supply of critical imported plant and equipment.

In May 1919, the first regular passenger electric train services commenced on the Sandringham and Essendon suburban railway lines. By 1923, this ambitious project for electrification of the suburban railway lines was effectively completed. At the time, it was claimed to be the largest suburban railway network in the world to be successfully converted from steam locomotive to electric traction. It was an immediate success in terms of increasing rail patronage and reducing operating costs.

The improved service provided by the electrification materially assisted in the continued growth of the Melbourne metropolis.

2. Heritage Award Nomination Letter

Learned Society Advisor
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: Electrification of Melbourne's Suburban Railway Network

The above-mentioned work is nominated to be awarded an Engineering Heritage National Marker.

Location: The system is located throughout the suburban area of Melbourne

Owner: VicTrack on behalf of the Victorian Government

Supervising Agency: Public Transport Victoria (PTV)

Operator: Metro Trains Melbourne

The owner will be advised of this nomination once it has been approved by EHA and a letter of agreement from the owner to recognise the site will be sought.

Access to site: Railway Stations are accessible to the public. Tracks, Substations, Workshops and other technical facilities are not accessible to the public but can be accessed with approval and supervision by the Owner/Supervising Agency/Operator.

The Nominating Body for this nomination is Engineering Heritage Victoria

David LeLievre
Chair
Engineering Heritage Victoria

Date: April 2019

3. Heritage Assessment

3.1 Basic Data

Location: Metropolitan Melbourne, Victoria

Owner: VicTrack on behalf of the Victorian Government

Operator: Metro Trains Melbourne

Current Use: Still in service

Designer: Merz & McLennan (UK) [Original system]

Maker/Builder: Various overseas electrical equipment manufactures, Victorian Railways Department and local contractors.

Year Started: 1912

Year Completed: 1923 (original scheme)

Physical Description: Electrification of a large, formerly steam locomotive operated suburban railway network, including electricity generation, transmission, conversion (AC to DC), overhead structures and wiring, track bonding, electrical rolling stock and automatic electric signaling.

Modifications: Modifications from 1923 to date include various extensions, line duplications / triplications and some line closures; new substations plus replacement of early substation plant and equipment and cessation of 25 Hz electricity generation; Melbourne Underground Rail Loop in the CBD (1971-82); successive generations of rolling stock.

3.2 Heritage Listings

The suburban railway network and its electrification does not have an existing heritage listing per se. A number of railway station buildings on the electrified network and some of the original large rotary converter substation buildings are individually listed on the Victorian Heritage Register and/or the Victorian Heritage Database.

3.3 History

The first moves

It appears that a representative of the General Electric Company (USA) made the first proposal for electrification of the Melbourne suburban railway network in 1896. The proposal was rejected by the then VR commissioners on the basis of the high cost of

conversion relative to perceived economic benefit. Two years later a Victorian Legislative Council Select Committee was established to look at possible electrification recommended proceeding on a number of the suburban lines, but again, this did not proceed.

In 1903 another Parliamentary Select Committee advocated that at least the Flinders Street to St Kilda line be electrified as a forerunner to converting other suburban lines. In response, the Chairman of the Victorian Railways Commissioners, Thomas Tait, in a memorandum to Thomas Bent, the then Minister for Railways, argued that in view of the expenditure that would be involved in converting the principal Melbourne suburban lines to electric traction, a thorough investigation should be undertaken by a consulting engineer with experience in electric railways. In this respect, Tait asserted that a final determination should 'be fortified by the best advice procurable' (Dornan & Henderson, 1979).

Tait's counsel was accepted, and in due course the government authorised him to select a consulting engineer who would visit Melbourne and report on the advisability of converting the suburban railways to electric traction and to recommend the most suitable system to be utilised. To this end, it was agreed that Tait would make enquiries about suburban railways that had been converted to electric traction and to identify a suitably qualified and experienced consulting engineer during an already planned overseas trip in 1907. Tait embarked on this assignment in 1907 and visited electric railways in Italy, Germany, France, USA and England.

In his subsequent report to the Government (Tait, 1907), Tait noted the then main competing electric traction systems were DC and single-phase AC, with either third-rail or overhead current collection. He also presented his views on the best design for future suburban passenger carriages, utilising sliding rather than swing doors for each seating compartment and incorporating a central aisle to permit passenger movement between seating compartment rows. This would enable greater advantage to be taken of Victoria's wide gauge lines (1600 mm) in terms of carriage width and thus passenger numbers that could be accommodated.

From his overseas trip, Tait recommended the appointment of Charles Merz from Newcastle-on-Tyne to investigate and report on electrification of the Melbourne suburban railways. Merz had acquired experience in the electrification of the North Eastern Railway in England and in particular, of its suburban lines around Newcastle. In the UK, Merz, although then quite young, was held in high regard for his professional expertise as an electrical engineer. Merz entered into an agreement with the Victorian Government to provide consulting engineering services and arrived in Melbourne in November 1907, to commence the assignment.

Charles Merz submitted his detailed report (Merz, 1908) to the Victorian Government in June 1908. In it he recommended proceeding with electrification of the Melbourne suburban railway system in three stages with a total route length of 218 miles (350 km). For traction supply he considered overhead 10 kV single-phase AC (with transformers in the motor cars supplying AC commutator motors) and 800 volt DC via a protected third-rail. On the basis of comparative cost estimates he concluded strongly in favour of the latter. After considering the limited public electricity supplies then available in Melbourne he determined that the Victorian Railways

would have to build its own power station, and proposed that this be located at suburban Yarraville, 13 km west of the CBD. The proposed power station would need to be able to supply a load of 35 000 hp (26 MW) with transmission at 12 kV, 3-phase AC, to some sixteen rotary converter substations with total capacities ranging from 1500 to 6000 kW. Based on his cost estimates, Merz showed an overall economic benefit by converting from steam locomotive to electric traction.

The railway commissioners were generally accepting of the technical aspects of the Merz report but disagreed with his economic analysis, considering that the latter was too optimistic. As a result the commissioners recommended to the Government against proceeding immediately, advocating instead to keep the issue under review and in the meantime that any upgrading of lines, rolling stock, signaling, etc., should be undertaken such as to facilitate a future move to electrification. This was accepted and in the years immediately following existing swing door passenger carriages were lengthened and strengthened to permit conversion for electric traction. New passenger rolling stock took the form of wider, sliding door compartment carriages with an internal aisle, as earlier proposed by Tait after his 1907 overseas trip.

Commitment

The electrification matter did not rest for long. In 1910 the State Government appointed a Royal Commission to ‘inquire into and report upon the railway and tramway systems of Melbourne and Suburbs’. This commission duly submitted its findings in the following year (Royal Commission, 1911). The key recommendations of this report were for the various private and municipally owned/operated Melbourne cable and electric tramways be taken over by a single government entity and that electrification of the suburban railway network proceed forthwith, the latter despite a contrary submission by the Railway Commissioners. The government accepted the Royal Commission’s key recommendations and early in 1912 re-engaged Charles Merz to review and update his 1908 report.

Merz brief included assessing the most suitable traction supply system for some 150 route miles (240 km), equating to 324 miles (518 km) of electrified tracks, inclusive of sidings. This amounted to around 68 miles (109 km) of additional track compared to the 1908 extent. He was also to consider possible extension of the electrified suburban network to some country lines.

Merz submitted his second report in July 1912 (Merz, 1912). His cost analysis this time was based on formal tenders for major plant and equipment from international companies for an overhead traction supply system operating at 1500 volts DC or at 11 kV single-phase AC. From his detailed cost analysis, Merz concluded that the 1500 volts D C overhead system would be the more economically and operationally favourable system for the Melbourne suburban railway network, and also for possible extension to more heavily trafficked country routes such as the Melbourne to Bendigo railway.

In a October 2012 Report of a review by the Victorian Railways Commissioners of Merz Report (Victorian Railways, 2012), addressed to the then State premier, William Watt, the commissioners advised their concurrence with the technical and financial

findings of the Merz Report and recommended that the electrification project be proceeded with, albeit with a proposed change to the staging of the works.

A Legislative Assembly Select Committee separately closely assessed the new Merz report including exhaustive examination of witnesses, Charles Merz; E B Jones - Acting Secretary for Railways; William Stone – Electrical Engineer Railways Dept.; and William Fitzpatrick – Chairman of the Railway Commissioners. Their report (Select Committee, 1912) generally endorsed the Merz report and its cost figures. In December 1912, following further extensive debate, the Victorian parliament approved proceeding with the recommended electrification project.

Implementation

It is interesting to note that at the time of Merz's second report the 1500 volt DC overhead traction system does not appear to have used anywhere else in the world for electrification of a major passenger suburban railway. The claim in Dornan & Henderson, 1979, that it was a first appears to be supported by information on early high voltage DC traction systems in Duffy (Duffy, 2003). Whilst there were a number of high voltage D C traction systems in American by then, they were for mainline applications and typically freight haulage railways. At the time there was certainly no prior British experience with the first UK installation being a 30 km freight only railway owned by the North Eastern Railway in Britain that was converted to 1500 volts DC traction in 1915. Significantly, Merz & McLennan were the North Eastern Railway's consulting engineers. The same company had previously engaged Merz to engineer the electrification of its Newcastle-on-Tyne suburban railways in 1904 (a 630 V DC third rail system).

To power the electrification, Merz again proposed a dedicated power station be constructed at Yarraville with six steam turbine generator sets to provide a maximum continuous capacity of 75 MW, more than double what had been envisaged in 1908. This was in order to serve the increased suburban track length and the significantly increased traffic (then and projected), plus allowance for supplying the load of the then small railways owned Spencer Street power station (that also supplied government buildings) and the railways operated St Kilda to Brighton electric tramway. The expansion, coupled with the possibility of electrifying some country lines was also Merz's justification for moving to 1500 volts DC, compared with the 800 V DC third rail system that he had proposed in 1908. The Railway Commissioners subsequently advocated and obtained Merz agreement for the power station to be located further south at Newport where it would be adjacent to the mouth of the Yarra River and as such, condenser-cooling water and its discharge could be more readily arranged.

Merz & McLennan were duly appointed as the lead engineers for construction of the electrification scheme. Charles Merz returned to England to arrange the letting of contracts for the major electrical equipment. A Mr E P Grove was appointed as Merz & McLennan's superintending engineer. He arrived in Melbourne in October 1913 and liaised with the Victorian Railways on implementation of the scheme. At this time it was anticipated that the first electric train service from Sandringham to Broadmeadows would be operating by mid 1915 with the entire electrification completed by 1917. In the event, the intervention of the First World War (1914 – 18)

caused a major disruption to the program, with equipment orders from UK electrical plant manufacturers being deferred to support the war effort. Alternative sources were sought with some equipment being obtained from the USA where manufacturers were largely unaffected by the war. The Victorian Railways arranged building and civil engineering works, but some of this work was also held up pending obtaining necessary information from major plant and equipment suppliers, and the availability of local materials.

The dedicated power station at Newport ultimately contained 12 black coal fired water tube boilers that supplied superheated steam at 210 psi (1.45 MPa) and 320 ºC into a common steam range (header). Six steam turbine-generator sets (4 x 12.5 MW and 2 x 14 MW maximum continuous rating) occupied the turbine hall. Their 3300 V at 25 cps (Hz) output was stepped-up by oil-cooled transformers to 20 kV for transmission to the traction substations. The latter was achieved by either three core underground cables or overhead lines with the latter mainly in outer areas and typically arranged at high level on one or both sides of the traction supply structures.

Some sixteen substations (four more than originally planned) were arranged at strategic locations along the various suburban railway routes to supply the 1500 V DC traction power. These took the form of substantial buildings with the first seven being built in grand style using brickwork. Later substations were able to take advantage of more compact ironclad, high-voltage AC switchgear that had been developed by the English Reyrolle company by the end of the war, and were built to a less elaborate design using concrete construction. Each contained one or more rotary converter machines that in conjunction with a step-down transformer converted the 20 kV AC supply from the power station to 1500 volts DC for the electric traction system. At the time, rotary converters, that combined an AC synchronous motor and a DC generator into one machine, were the most efficient option for the power levels involved. The practical difficulty of making a 1500 V DC rotary converter suitable for operation from a 50 Hz AC supply – as was by then being used in Melbourne and elsewhere for AC public electricity supply – was the reason for 25 Hz AC frequency being chosen for the dedicated railways power station at Newport. With the wartime exigencies, rotary converters were supplied by Siemens Bros., Metropolitan Vickers and British Thompson Houston companies in England and by General Electric in the USA. The converter capacities ranged from 750 to 4500 kW with the larger substations typically having multiple machines. The largest substation near Princes Bridge (later referred to as Jolimont substation) had four 4500 kW rotary converter machines, each housed in a segregated brick bay inside the substation building.

The overhead typically wiring consisted of trackside lattice steel masts supporting a cross beam from which hung via insulators a catenary cable that in turn supported the contact wire by means of a series of droppers. The contact wire of hard drawn copper was tensioned at intervals by means of pulleys and dead weights. The design of the structures was by Merz & McLennan with foundations, fabrication and erection undertaken by the Victorian Railways. The British Insulated and Helsby Cables Ltd supplied the overhead electrical items including insulators, catenary and contact wires. The work over running tracks was undertaken at night and weekends with minimal interruption to the steam hauled suburban train services.

Electric Rolling Stock

Prior to Merz's first report in 1908 the V R had trialed extending the length of its then twin bogie, swing-door suburban passenger cars from 13.7 to 17.4 m with a strengthened steel underframe. Merz, in his 1908 report commended this initiative with a rider that the underframes should be constructed and further strengthened so that they could support motor car electrical equipment and as such be able to be used on a future electrified system. (Dornan & Henderson, 1979).

Following the Chairman of Commissioners, Thomas Tait's overseas trip in 1907, new passenger rolling stock was manufactured at the V R's Newport workshops to his design – the 'Tait ' cars. These wider bodied cars with sliding doors for access to each compartment and a central aisle could accommodate more passengers. Like the retrofitted earlier swing-door cars, the steel underframes were designed to be able to support future electrical equipment.

Following the 1912 decision to proceed with electrification, Tait cars and lengthened and strengthened swing-door cars destined to serve as electric motor cars on multi-unit electric trains were fitted with General Electric supplied pantographs, electric traction motors and electrical control gear as per the General Electric Type M control system.

Each axle on the four wheel bogies was arranged to be gear driven by a 140 hp (104 kW) 750 V DC series connected (motor field coils in series with the armature winding) with the pair of 750 V motors then permanently wired together as a series connected pair. On this basis, the driver's drum type controller could, via contactors suspended under the car, first connect the pairs of permanently series connected 750 V motor on each of the motor car's two twin axle bogies in series for starting and low speed running and then transfer to 'series – parallel' with the pair of motors on each bogie the connected across the full 1500 V DC from the overhead for higher speeds. Before and after the all series, to the series – parallel connection, the driver's drum controller, again via contactors, successively shorted out series connected grid resistors to progressively accelerate the train. A further final two steps on the controller gave top speed running by shorting out parts of the motor field winding and thus weakening the magnetic field in each traction motor. The maximum speed attainable was 83 km/h on level track. (Dornan & Henderson, 1979).

The use of contactors suspended beneath each motor car to control its traction motors, as outlined above, enabled a multi-unit electric train with two or more motor cars to be controlled via the drum type controller in the driver's cabin of any motor or 'driving trailer' car. This was achieved by means of a common 9-core control cable that ran the length of the multi car train with plug and socket connections between each motor and trailer car. This multi-unit concept was first developed by Frank Sprague (USA) in 1897. Accordingly, by placing a motor car or a driving trailer at each end of a multi car electric train, a driver had to simply change to the opposite end driver's cabin to reverse the direction of running and operate a reverser switch. With an intermediate motor car or driving trailer, the multi car train could also be reduced in length if desired for operation at times of lower traffic volume.

Each motor car was also fitted with an under mounted 1500/750 volts dual commutator 'dynamotor' that supplied 750 V DC for operation of the traction control

circuitry. This also supplied incandescent lighting via series connected lamps that were mounted in the former Pintsch gas lighting fittings in the passenger compartments of both motor and trailer cars. A 1500 V DC motor driven air compressor under each motor car supplied compressed air for the automatic Westinghouse air brake system. In accordance with normal practice, air supply and a common brake pipe ran the length of the multi-unit train with flexible hose connections between each car.

By 1919 there was a total of 702 individual passenger cars available for use, although not all fitted out, on the electrified suburban railway lines, comprising 359 motor cars, 56 driving trailer cars and 287 non-driving trailer cars. Fifty-five percent of the total were 'Tait' sliding door cars and the balance being the modified swing-door cars (IAMS, 1919). At the end of the 1923-24 financial year, the total number of electric passenger cars had increased to 763 plus 3 electric parcels vans. In addition, two 'steeple cab' electric locomotives were then in use for yard shunting duty, but with the intention of being used for suburban goods services when sidings at major suburban centres were electrified. (V R Annual Report, 1923-24).Extensive electric car workshops were established in Jolimont along with a training facility for electric train crews.

After testing and driver training on the Flemington Racecourse branch line in late 2018, and a successful running of an artificially loaded test train between Sandringham and Essendon in the early hours of Sunday 18 May 1919, the electrification was officially opened on 28 May 1918. For this occasion, a flag bedecked official electric train ran from Flinders Street station to Essendon station where the then Acting Prime Minister, William Watt, who had been the Victorian premier when the scheme was initiated and had enthusiastically supported it, formally inaugurated the service at a short ceremony. The official train then proceeded to Sandringham station where another ceremony took place before the train returned to the city. At 5.10 am on the following day, regular public electric train services commenced between Sandringham and Essendon stations. (Dornan & Henderson, 1979).

The electrification of the Melbourne suburban railway lines under the original scheme attained practical completion in April 1923 with the completion of the electrification of the Heidelberg to Eltham section. The First World War, particularly in regard to the procurement of critical imported electrical equipment and increased labour costs, materially impacted the construction time and the overall cost. The final capital cost in 1923 totaled to £6.27 M compared with the original 1912 estimate of £3.99 M (Lee, 2007) The early success of the electrification, with its faster and more frequent services was however dramatically reflected in the large increase in patronage. This rose from just under 97 M in 1917-18, the last year of all steam operation, to 158 M in 1923-24, a 63 percent increase. On some lines the passenger traffic had increased by more than 100%. (V R Annual Report, 1923-24). The resulting increase in revenue was also complemented by a reduction in operating costs with fewer personnel being required and lower net fuel costs (Dornan & Henderson, 1979).

Automatic Signaling

In his 1912 report, Merz had not seen a necessity to significantly upgrade signaling and no allowance was therefore made by him to do so. However the V R Commissioners had separately been keen to equip two, four and six track suburban lines with automatic or semi-automatic signaling and associated train stops. This would improve operational safety, an important consideration in view of several serious accidents in the past, and particularly so with the expected faster and more frequent electric train services. In 1913 the V R's Engineer of Signals visited the U K, Europe and America to assess alternative signaling systems. After due deliberation, it was decided to adopt the three-position American 'speed signaling' system, utilising electric motor driven upper-quadrant semaphore type and/or coloured light only trackside signals, with automatic operation via electric track circuits. (Dornan & Henderson).

In order to power the new electric signaling in conjunction with the electrification project, a 2200 V, 25 Hz, single-phase signaling power supply was arranged from individual traction substations. The 2200 V AC signaling supply was then reticulated in trackside trunking that also contained signal control cables. Transformers in signaling equipment rooms and trackside cabinets stepped the 2200 V supply down to 110 V for operation of the signals and to 6 V for associated 25 Hz track circuits. As the latter required the rail tracks between each signal to be insulated from the track sections on each side, 'impedance bonds' consisting of inductors were installed across each insulated track section to permit return of the DC traction current to the substations whilst allowing an AC track circuit relay connected across adjacent rails in the section to remain energized until the rails were 'bridged' by the wheels and axles of a train entering and traversing the particular track section. Additionally, motorized train trips were arranged at the beginning of each signal track section and adjacent to the signal protecting it to automatically stop a train that entered the section whilst the signal was at 'Stop'. (IAMS, 1919).

Although intended to cover the entire electrified network, funding constraints slowed the roll out of electric signaling. Despite savings available by removing signal boxes and signalmen from tracks not involving points for diverging / converging routes, only about 60 percent of the network's signaling had been upgraded by 1933 and no more was done until after World War 2 (Dornan & Henderson, 1979). At track junctions where signals and points had to be interlocked, this typically continued to be achieved by the original, large lever mechanical interlocking frames inside nearby signal boxes. In this case, semi-automatic electric signals protecting the turnouts were operated by electrical switches attached to the respective signal levers whilst the track points and their locking mechanisms continued to be operated via mechanical rodding. However, by the end of the original electrification project, the signal boxes at a few junctions had been equipped with new miniature lever electro-mechanical interlocking machines with the points then operated by electric motor based point machines. The use of coloured light only signals rather than the upper quadrant semaphores was also becoming more widespread. (V R Annual Report, 1923-24).

In its report for the financial year 1923-24, the Railways Department stated that: 'the value and safety of the electrification system has been considerably increased by the installation of automatic signaling and train stops'. It allowed increases in train carrying capacity by enabling reduced headways between following trains than could not have been practically achieved with manually controlled mechanical signals.

Typical headways on the electrified and automatic signaled lines were now down to 3 minutes and as low as 2 minutes on some sections. (V R Annual Report, 1923-24).

For more information on the history of development and technical details of the original electric traction system, including the Newport power station, readers are directed particularly to Dornan & Henderson, 1979 and The Industrial Australian and Mining Standard special issue publication, (IAMS, 1919). (See References section).

4 Assessment of Significance

4.1 Historical Significance

At the time of its implementation, the electrification of the Melbourne suburban railway network was claimed by the Victorian Railways to be the largest suburban railway network in the world to be successfully converted from steam locomotive to electric traction.

- It was an immediate success in terms of increasing rail patronage as a consequence of improved service – faster and more frequent trains – and operating costs were reduced

- It included the construction of a dedicated 78 MW coal fired power station (at Newport) that was claimed to be the largest power station in the southern hemisphere at the time of its completion.

- It was a pioneer in the application of 1500 volts DC traction to a large suburban passenger railway system.

- It included the introduction of new, high capacity sliding door, multi-car, passenger rolling stock – 'Tait trains' – that remained in service as electric rolling stock for 65 years. The last Tait train was retired from service in December 1984 (Lee, 2007).

- The introduction of an automatic speed signaling system based on employing upper quadrant, motorized semaphore and coloured light trackside signals operated by AC track circuits plus automatic train stops. This was a first use of this form of railway signaling in Australia and enabled shorter headways between trains with a corresponding ability to improve service frequency.

4.2 Historic Individuals and other contributors

The most visible individuals associated with development of the original electrification scheme were Thomas Tait and Charles Merz.

Thomas James Tait

Thomas James Tait was born in Melbourne, Quebec, Canada, on 24 July 1864, as the son of an eminent lawyer. He was educated at Montreal High School and McGill University and in 1880 commenced employment with the Grand Trunk Railway Company. He served in a variety of administrative positions with both the Grand Trunk Railway and the Canadian Pacific Railway Companies. In 1890 Thomas married Emily St Aubert Cockburn. His railway career continued to prosper and by 1903 he held the position of manager of transportation with the Canadian Pacific Railway Company.

In March of 1903, the then premier of Victoria, (Sir) William Irvine, arranged for the appointment of Tait as Chairman of Commissioners of the Victorian Railways. Tait

was faced with reducing the cost to the government of the railways post the 1890s depression, a task in which he ultimately succeeded such that the government owned railways department returned a net profit. In response to the 1903 Select Committee’s recommendation that a start should be made on electrification of the Melbourne suburban railway network, Tait successfully argued that before any decision was made, a full study and assessment of electrification should be commissioned from the best available international consultant in the field. As related earlier, he was subsequently charged with identifying a suitable consultant and in 1907 also toured overseas to see and enquire firsthand regarding the electrification of suburban railways.

When the consultant that Tait selected, Charles Merz, submitted his report in 1908 and recommended proceeding with electrification, Tait, supported by his fellow commissioners, successfully argued against any immediate commitment on economic grounds.

Tait was reputed to be a man of strong opinion and used to getting his own way. He resigned from the Victorian Railways in 1910 and was knighted for his services in 1911. He retuned to Canada later the same year and following a brief government appointment there in 1913, he retired to private life. Thomas Tait died in St Andrews, New Brunswick, Canada, on 25 July 1940.

Tait’s lasting legacy to the Victorian Railways was the sliding door, central corridor suburban passenger car that came to be known as the ‘Tait Car’ and when assembled as multiple units, a ‘Tait train’. Whilst in favour of eventual electrification in principle, he believed it to be premature during his tenure with the Victorian Railways.

Reference: Australian Dictionary of Biography.

Charles Hesterman Merz

Charles Hesterman Merz was born in Gateshead, England, on 5 October 1874, the eldest son of distinguished industrial chemist John Theodore Merz and Alice Mary Richardson. He attended Armstrong College (later King’s College) Newcastle-upon-Tyne and then entered an apprenticeship at the Newcastle-upon-Tyne Electric Supply Company that had been founded by his father and R S Watson.

In 1894 be was a pupil at Robey & Co., Engineering Works, in Lincoln and subsequently superintended contracts for the British Thomson-Houston Company (BTH) at the City of London Electric Lighting Company’s Bankside power station. At age 23 he rose to the position of manager and engineer to operate the plant that BTH had furnished for electricity supply in Croydon.

In 1898, the young Merz became the first Secretary and Chief Engineer of the Cork Electric Tramways and Lighting Company, Ireland. A year later he set up an independent consulting engineering practice that became Merz & McLennan when William McLennan, with whom he had worked with in Cork, joined with Merz.

The next major project for Merz was the Neptune Bank power station in Wallsend, near Newcastle, which was one of the first 3-phase AC electricity supply enterprises in Britain. He returned to involvement with electric traction as consultant to the local tramway company on electrification of their Tyneside horse tram routes and then for the electrification of the Tyneside local railway lines of the North Eastern Railway.

In 1905 Merz unsuccessfully sought to persuade the British Parliament to unify the then wide variety of voltages and frequencies used in the country's public electricity supply utilities. His continuing advocacy did however see him appointed as head of a parliamentary committee to investigate the matter at the end of WW1.

As elaborated earlier, Merz consulted to the Victorian Government in relation to prospective electrification of the Melbourne suburban railway network in 1907-08 and again in 1912, with the latter leading to a decision to proceed with Merz & McLennan then acting as consultants for its implementation.

In 1913 Charles married Stella Byrne de Satur, and together they had a son and a daughter.

In 1916 Merz representations to establish a national electricity grid led to the Williamson Report of 1918 that in turn hatched the Electricity Supply Bill, 1919. This was followed by Merz becoming a member of the Weir Committee from which came the UK's Electricity Supply Act, 1926, that in turn led to the setting up of the national grid network to interconnect power stations and supply industry and other consumers.

Merz provided finance for Bacon's early work on fuel cells and in 1940, designed the electric drive equipment for the TOG 1 military tank.

On 15 October 1940, an enemy bomb that demolished his then home in Kingston, London, killed Merz, along with his two children and two servants.

Reference: Grace's Guide.

Australian Input

Whilst the design of the original scheme, the calling of tenders and placing of orders for supply of the main electrical equipment was by Merz & McLennan, who also had their resident engineer (Mr Grove) in Melboune to liaise with the V R during the construction, engineers in the V R's civil, mechanical and electrical engineering branches were extensively involved in the construction. Also, where practicable, local materials and contractors were used.

The Tait passenger cars used on the electrified system were Australian designed and made at the V R's Newport Railway Workshops, albeit that they had imported – from G E (USA) – electrical equipment arranged by Merz & McLennan.

Also, concurrent with the original electrification project, the V R investigated and subsequently proceeded with the introduction of automatic electric signaling. As stated elsewhere, this enhanced the benefit of the electrification scheme by permitting shorter headways between successive trains on dual or triple track routes.

4.3 Creative or Technical Achievement

The electrification of the Melbourne suburban railway network was at the vanguard of using high voltage direct current, viz; 1500 V DC, for a large scale suburban railway system. Hitherto, a lower voltage such as 600 – 800 volts with insulated third-rail current collection was commonly adopted for more compact electrified suburban railways in the UK and Europe. Compared with cities in both of these locations, metropolitan Melbourne had a much lower population density with its suburbs extending further out from the CBD. This favoured the use of a higher voltage in the interests of reducing the number of traction substations required to service the extended network.

The introduction of automatic signaling using upper quadrant semaphore and coloured light trackside signals, as mentioned above was also pioneering in the Australian context.

4.4 Research Potential

The conversion of Melbourne's suburban railway network from steam locomotive to electric traction has been widely documented – see references – and as such remaining research potential is limited to possible further investigation of detail technical issues.

4.5 Social

The social significance for the commuters of Melbourne was and is considerable. Suburban train services became cheaper, services more frequent and train operation was much cleaner (without steam locomotives) and reliability higher. The availability of the suburban train system facilitated the rapid growth of industry and commerce in Melbourne. This advantage came earlier than in other Australian capitals and remains a strategic advantage to modern times.

4.6 Rarity

Most major cities of the world that had suburban railways adopted electric traction and multi-unit trains, either at the outset or, as in Melbourne, converted over from steam locomotive to electric traction. Sydney followed Melbourne's lead with their first electric train service commencing in 1926, and like Melbourne, used 1500 V DC for traction supply. As such, the Melbourne electrification is not considered to be rare, beyond that it was a pioneer in the use of 1500 V DC for a suburban railway.

4.7 Representativeness

The electrified Melbourne suburban railway network is representative of similar 1500 V DC suburban electric traction systems elsewhere in the world that originated in the early part of the twentieth century, with the added aspect that it appears to have been the first to adopt 1500 V DC with overhead current collection. The Melbourne system has been expanded and otherwise modified over the years, but most of the original rail

routes and electrification infrastructure remains extant. The only comparable system in Australia is the Sydney suburban railway network that also uses 1500 V DC and whose first electric train service commenced some seven years after Melbourne.

4.8 Integrity / Intactness

One of the key features of the Melbourne Suburban Railway Electrification system is the fact that it has survived for 100 years substantially intact and has maintained its integrity in most respects. The design of the trains have changed over time, the system has been extended as Melbourne has grown and some new technologies have been incorporated such as solid state rectifier stations in the place of the magnificent rotary converters of the original system.

4.9 Statement of Significance

The electrification of the Melbourne suburban railway network in the second and third decades of the twentieth century was significant for the following reasons:

- At the time of its implementation it was considered to be one of the largest and most important railway electrification schemes yet carried out (The Engineer, 1920).
- It was an immediate success in terms of increasing rail patronage as a consequence of improved service – faster and more frequent trains – and operating costs were reduced
- It included the construction of a dedicated 78 MW coal fired power station (at Newport) that was claimed to be the largest power station in the southern hemisphere at the time of its completion.
- The electrification had a positive societal impact that facilitated the ongoing development of metropolitan Melbourne.
- It was a pioneer in the application of 1500 V DC traction to a large suburban passenger railway system.
- It included the introduction of new, high capacity sliding door, multi-car, passenger rolling stock – Tait trains – that remained in electric train service for 65 years.
- The introduction of an automatic speed signaling system based on employing upper quadrant, motorized semaphore and coloured light trackside signals operated by AC track circuits. This was a first use of this form of railway

signaling in Australia and enabled shorter headways between trains with a corresponding ability to improve service frequency.

- With extensions to the area of coverage, the successive introduction of newer technology rolling stock and upgrades to the substation AC to DC conversion plant, the electrified network has served metropolitan Melbourne for a century and it continues to do so.

4.10 Area of Significance

The electrification of the Melbourne suburban railway network was a first such initiative in Australia, and in its pioneering of 1500 V DC electric traction, it was at the time significant on a world basis.

It should therefore be considered for an Engineering Heritage National Marker.

5 Interpretation Plan

5.1 General Approach

As the centenary of the first electric train service in Melbourne is on the 28th (official opening) and 29th (commencement of regular service) of May this year, it would be opportune to arrange a ceremony to unveil an engineering heritage recognition marker and interpretation panel(s) on or soon after those dates. If the Tait train that has been restored by the Elecrail division of Steamrail could be arranged to re-enact the first electric train running, potentially with the official party, stakeholder representatives and other guests onboard, the sense of occasion and public interest would be greatly enhanced.

It appears that due to current works on the network and some outstanding technical and operational issues yet to be resolved in relation to running of the restored Tait train on the present electrified network, the latter is unlikely to be practicable until later in the year. Whilst by then the centenary date will have passed, it would still be in the centenary year.

It is suggested that the best place for a heritage recognition interpretive panel would be in a public circulation area at Flinders Street or Southern Cross stations where large numbers of suburban rail travellers could see the panel. An alternative would be at Essendon and Sandringham stations that were the sites of the 28 May 1919 official opening ceremonies. As such, the engineering heritage recognition panels would then only be visible to users of those stations. A further option could be for a main engineering heritage recognition interpretative panel at Flinders Street or Southern Cross station with sub-panels at Essendon and Sandringham stations.

The site or sites for the heritage recognition panel will have to be agreed with the various stakeholders and with VicTrack, as owner on behalf of the government, of the respective railway stations.

5.2 Interpretation Panel

Interpretation panels could be considered at several locations as detailed in 5.1 above. These panels will likely have the following characteristics:

1 A title “Electrification of Melbourne’s Suburban Railway Network”.

2 Logos of Engineers Australia and the various railway bodies involved to be incorporated.

3 A small scale representation of the EHA marker plate.

4 The date and other details of the marking ceremony.

5 Body text should be 24 point Arial Bold.

6 A map showing the layout of the Melbourne Suburban Railway Network as of the mid 1920s on completion of the initial works.

7 At least 4 images with brief captions.

8 Total text should not exceed 500 words excluding headings.

9 Size to be nominally 1200 mm wide by 600 mm high.

10 The panel to be preferably constructed of vitreous enamel-on-steel plate with flanges as per EHA standard drawings.

11 The panel to be mounted on a steel free-standing frame as per EHA standard drawings or be wall mounted.

12 The EHA marker to be mounted below the interpretation panel as per EHA standard drawings if the panel is frame mounted but may be omitted if the panel is wall mounted.

Possible Interpretation themes for Interpretation Panels

The following subjects have been assessed as possible themes for the interpretation panel:

a) The history of the Electrification of Melbourne's Suburban Railway Network
b) The story of the construction of the network between 1919 and 1923 including major technical features adopted.
c) The social benefits of the Electrification of the Melbourne Suburban Railway Network.

6. References

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Merz, 1912, *'Further Report by Charles H Merz upon the Application of Electric Traction to the Melbourne Suburban Railway System'* Government Printer, Melbourne.

Royal Commission, 1911, *'Report of the Royal Commission Appointed to Inquire into and Report upon the Railway and Tramway Systems of Melbourne and Suburbs'*, Government Printer, Melbourne.

Select Committee, 1912, *'Report of the Select Committee in connection with the Further Report by Mr Charles H Merz on the Application of Electric Traction to the Melbourne Suburban Railway System'*, Victorian Government printer.

Tait, 1907, *'Report of Mr Thos. Tait as to his inquiries in Europe and America in connexion with the question of the Electrification of the Melbourne suburban lines and the engagement of a consulting engineer to investigate and report in regard thereto'*, Victorian Government printer.

The Engineer, 1920, *'Electrification of the Melbourne Suburban Railways'*, The Engineer magazine, U K, 9 January 1920, pages 40 and 44 – 47.

Victorian Railways, 1912, *'Report of the Victorian Railways Commissioners in connection with the Further Report by Mr Charles H Merz on the Application of Electric Traction to the Melbourne Suburban Railway System'*, Victorian Railways.

V R Annual Report, 1923-24, *'Annual Report of the Victorian Railways, 1923-24'*.

Copies of Victorian Parliamentary Papers listed above may be accessed from:
https://www.parliament.vic.gov.au/vufind/Search/Results?lookfor=Railway+electrification&type=AllFields&submit=Find&limit=20&sort=relevance

7. Acknowledgements, Authorship and General Notes

7.1 Acknowledgements

The author acknowledges with thanks Mr Ian Cook of Metro Trains Melbourne for his thorough and constructive reviews of earlier drafts of this nomination.

7.2 Nomination Preparation

This nomination was prepared by Miles Pierce, with assistance from Owen Peake, on behalf of Engineering Heritage Victoria.

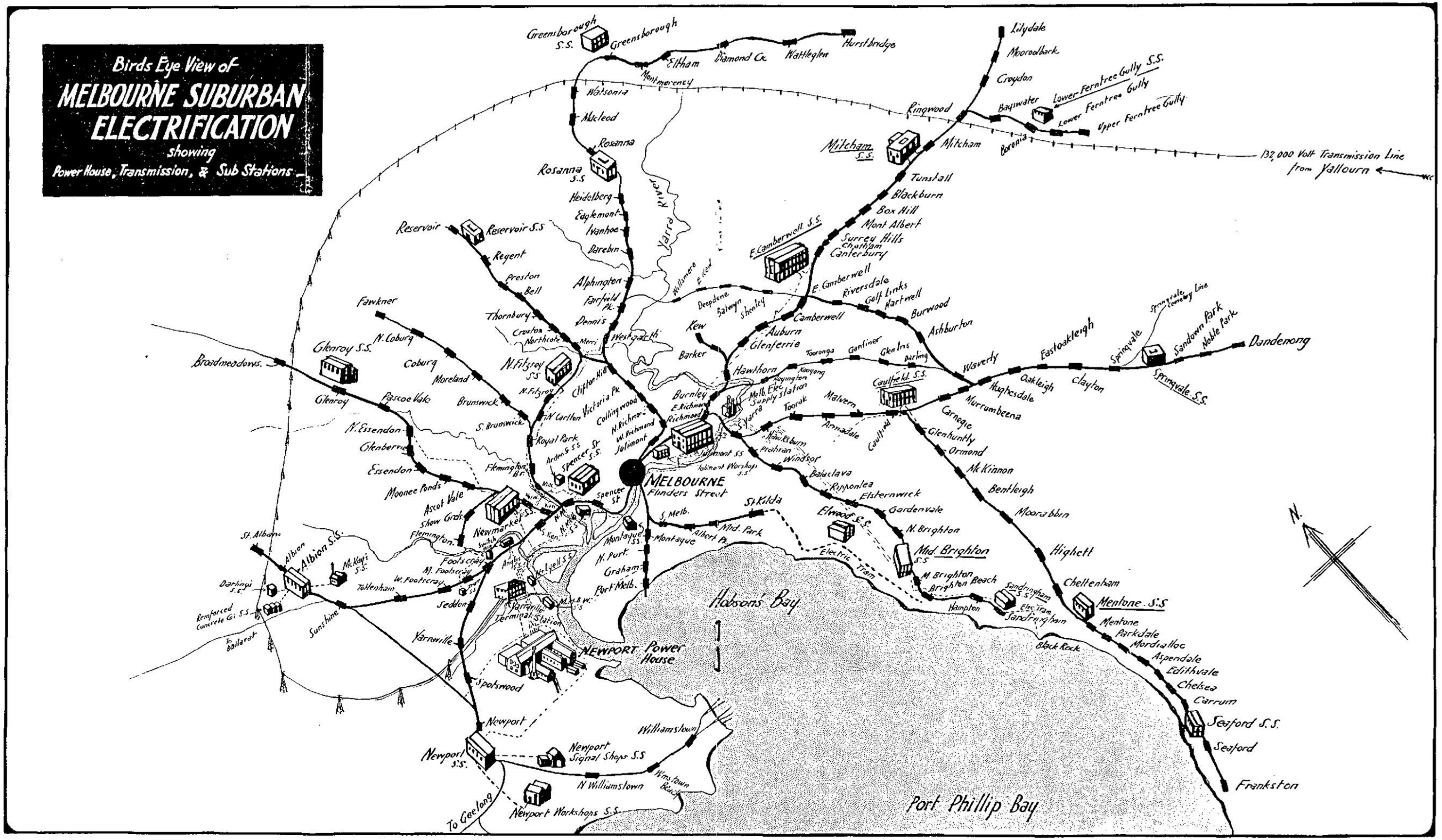
8. Maps

The following two pages contain maps of the electrified suburban railway network.

The first map is from the 9 January edition of *The Engineer* magazine (The Engineer, 1920).

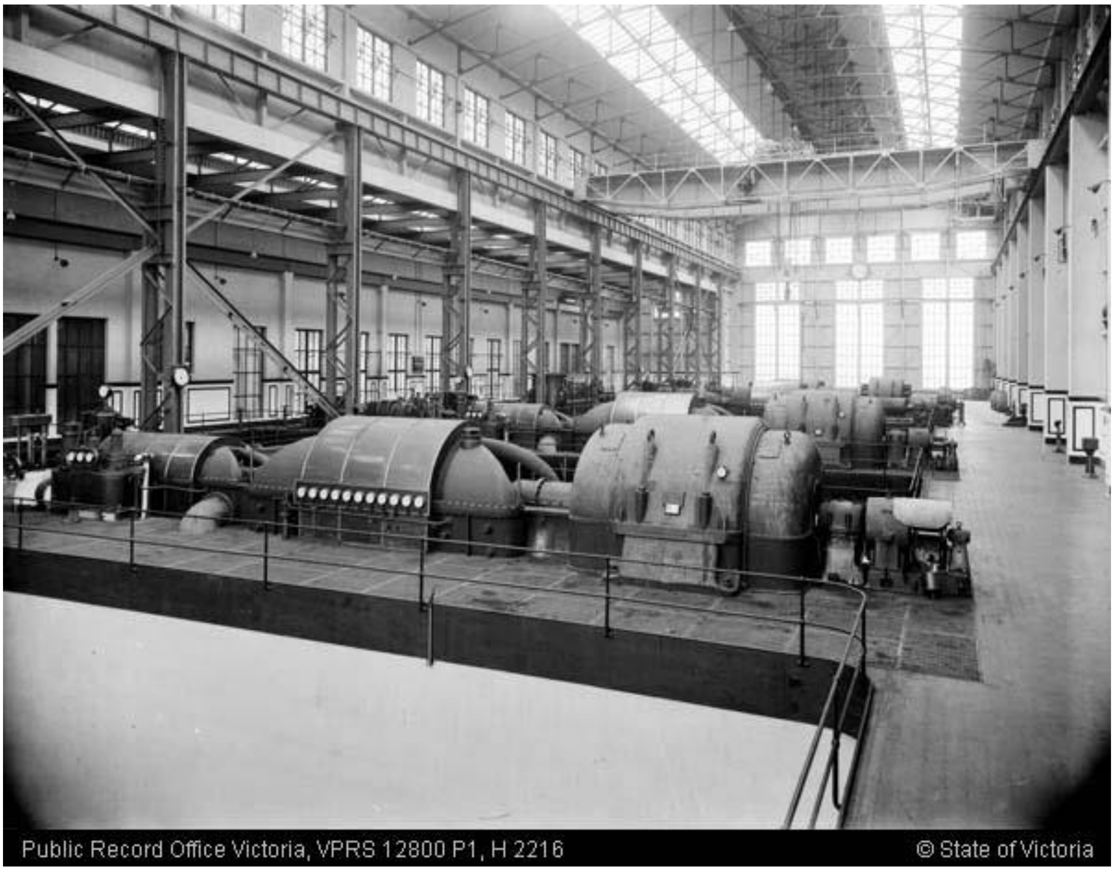
The second map is a stylised diagram from a Victorian Railways 1927 publication: 'Melbourne's Electric Railway System'. It shows the 1923 SECV Newport 'B' power station adjoining the V R's Newport 'A' power station, their interconnection at the nearby SECV Yarraville Terminal Station, and the connection of the latter to the 132 kV transmission line from the SECV's first Yallourn brown coal power station that came into service in 1924. The diagram also shows the substation at Spencer Street that replaced the earlier small Railways power station that was used to supply several government buildings in the CBD, and the substations at Elwood and at Sandringham used for powering the V R operated St Kilda to Brighton Beach and the Sandringham to Black Rock electric tramways respectively.


MAP OF SUBURBAN RAILWAY SYSTEM
Shewing Lines to be Electrified, Position of the Power Station Substations & the Proposed Routes of the 20 000 Volt Underground & Overhead Feeders
REFERENCES
Power Station & Substations
20,000 Volt Underground Feeders
20,000 Volt Overhead Feeders
1500 Volt Cross Country Feeders
MACLEOD S.S.
RESERVOIR S.S.
GLENROY S.S.
N. FITZROY S.S.
NEWMARKET S.S.
SPENCER ST. S.S.
ALBION S.S.
NEWPORT S.S.
NEWPORT POWER STATION
EAST CAMBERWELL S.S.
MITCHAM S.S.
CAULFIELD S.S.
SPRINGVALE S.S.
SEAFORD S.S.
MENTONE S.S.
MIDDLE BRIGHTON S.S.
BLACKROCK TRAMWAY S.S.
TRAMWAY


Birds Eye View of
MELBOURNE SUBURBAN
ELECTRIFICATION
showing
Power House, Transmission, & Sub Stations
132,000 Volt Transmission Line from Yallourn
MELBOURNE
Flinders Street
NEWPORT Power House
Hobsons' Bay
Port Phillip Bay
Yarra River
N.
Greensborough S.S.
Greensborough
Montmorency
Eltham
Diamond Ck.
Wattleglen
Hurstbridge
Watsonia
Macleod
Rosanna
Rosanna S.S.
Heidelberg
Eaglemont
Ivanhoe
Darebin
Alphington
Fairfield Pk.
Dennis
Westgarth
Reservoir
Reservoir S.S.
Regent
Preston
Bell
Thornbury
Croxton
Northcote
Merri
Fawkner
N. Coburg
Coburg
Moreland
Brunswick
S. Brunswick
N. Fitzroy S.S.
N. Fitzroy
Clifton Hill
Victoria Pk.
Collingwood
N. Richmond
W. Richmond
Jolimont
N. Carlton
Royal Park
Arden St. S.S.
Spencer St. S.S.
Spencer St.
Flemington Br.
Glenroy S.S.
Glenroy
Broadmeadows
Pascoe Vale
N. Essendon
Glenbervie
Essendon
Moonee Ponds
Ascot Vale
Show Grds.
Flemington
Newmarket S.S.
Footscray
M. Footscray
W. Footscray
Tottenham
Seddon
Yarraville
Spotswood
Newport
Newport S.S.
Newport Signal Shops S.S.
Williamstown
Wmstown Beach
N. Williamstown
Newport Workshops S.S.
To Geelong
St. Albans
Albion
Albion S.S.
McKay's S.S.
Darling's S.S.
Reinforced Concrete Co. S.S.
Sunshine
To Ballarat
Yarraville Terminal Station
S. Melb.
Montague S.S.
Montague
Albert Pk.
Mid. Park
St. Kilda
N. Port
Graham
Port Melb.
Electric Tram
Kew
Barker
Deepdene
Balwyn
Shenley
Willsmere
E. Kew
Burnley
E. Richmond
Richmond
Jolimont S.S.
Jolimont Workshops S.S.
Melb. Elec. Supply Station
Yarra
Hawthorn
Glenferrie
Auburn
Camberwell
E. Camberwell
E. Camberwell S.S.
Canterbury
Chatham
Surrey Hills
Mont Albert
Box Hill
Blackburn
Tunstall
Mitcham
Mitcham S.S.
Ringwood
Croydon
Mooroolbark
Lilydale
Bayswater
Lower Ferntree Gully S.S.
Lower Ferntree Gully
Upper Ferntree Gully
Boronia
Riversdale
Golf Links
Hartwell
Burwood
Ashburton
Tooronga
Gardiner
Glen Iris
Darling
Kooyong
Toorak
Malvern
Armadale
Caulfield
Caulfield S.S.
Hawksburn
Prahran
Windsor
Balaclava
Ripponlea
Elsternwick
Elwood S.S.
Gardenvale
N. Brighton
Mid. Brighton
M. Brighton
Brighton Beach
Hampton
Sandringham
Sandringham S.S.
Carnegie
Glenhuntly
Ormond
McKinnon
Bentleigh
Moorabbin
Highett
Cheltenham
Mentone S.S.
Mentone
Parkdale
Mordialloc
Aspendale
Edithvale
Chelsea
Carrum
Seaford S.S.
Seaford
Frankston
Black Rock
Waverly
Hughesdale
Murrumbeena
Oakleigh
Clayton
Eastoakleigh
Springvale
Springvale S.S.
Sandown Park
Noble Park
Dandenong
Springvale Cemetery Line

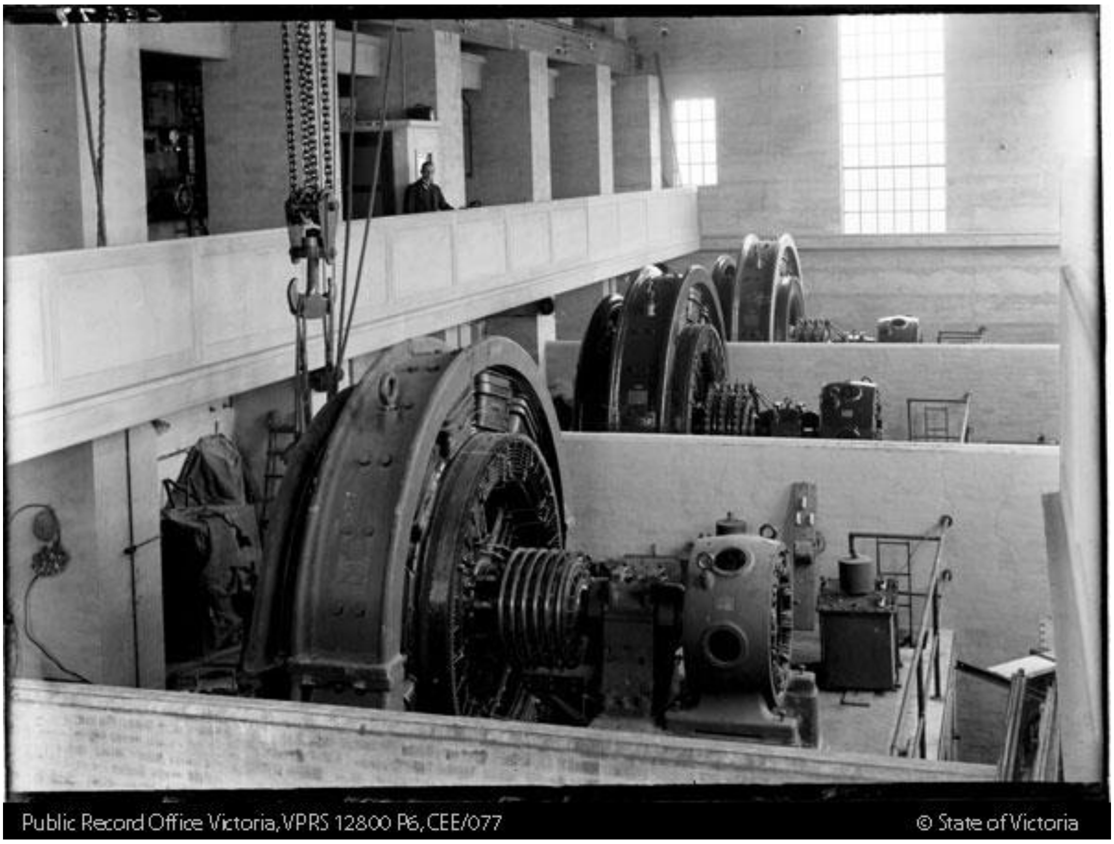
9. Photographs

Newport power station viewed from the Yarra River



Newport (A) power station Turbine Hall

Jolimont rotary converter substation



Rotary converters in segregated brick cells. Upper level operating galley at left

Overhead wiring and support structures. Tension structure with upper quadrant auto signals also mounted off it in the middle distance. View looking towards Richmond.

Double track line with overhead structures also carrying 20 kV power lines

Tait electric train on single track at right

Tait electric train at a suburban station

Interior of a typical sliding door Tait car with internal aisle

Steamrail's restored Tait train at Newport workshops   Photo – M Pierce

Tait motor car driver controls. Drum controller centre, air brake at left.   M Pierce

Crowd at Essendon station at the official opening of the electric service, 28 May 1919

Entrance (under ‘the clocks’) to Flinders St Station – Note cable trams in foreground

10. Change Control Block

VERSION 1	8 April 2019	Reviewed by O P 9/4
VERSION 2	9 April 2019	
VERSION 3	12 April 2019	Following Ian Cook review.
VERSION 4	18 April 2019	More I C input + Maps & Photos